# Walking Age Does Not Explain Term Versus Preterm Difference In Bone Geometry

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**Objective** To elucidate the relationship between bone geometry and onset of walking in former term and preterm children.

**Study design** We conducted a cross-sectional study of 128 preschool children aged 3 to 5 years who underwent peripheral quantitative computerized tomography measures of bone size at the distal tibia. Linear models were developed, stratifying by sex, to determine whether bone differences between children born term and preterm were caused by differences in walking age.

**Results** Children with a history of preterm birth walked later than children born at term (12.4 ± 0.5 versus 10.9 ± 0.2 months; $P = .004$); however, gestation-corrected walking age (11.4 ± 0.5 for children born preterm) did not differ. In multiple regression analysis, boys born preterm had larger periosteal and endosteal circumferences and smaller cortical thickness and area than boys born term (least square means, 49.7 ± 1.3 mm, 43.0 ± 1.8 mm, 1.1 ± 0.11 mm, and 49.3 ± 3.2 $mm^2$ versus 47.0 ± 0.5 mm, 38.5 ± 0.7 mm, 1.4 ± 0.04 mm, and 56.9 ± 1.2 $mm^2$, respectively; all $P < .05$). Preterm birth remained statistically significant after adding the age of walking to the models, but no longer significant when current activity levels were included.

**Conclusion** Greater periosteal and endosteal circumferences, with smaller cortical bone thickness and area, were found in former preterm boys, but not girls, and were explained by differences in current activity levels, not age of walking. *(J Pediatr 2007;151:61-6)*

Although genetics is the major determinant of bone mass, modifiable environmental influences, such as physical activity and diet, have been shown to optimize an individual's genetic potential.[1] In addition, infant birth weight and growth are thought to influence adult bone geometry.[2] An association between adult and childhood bone has been suggested, and peak bone mass attained in early life is considered to be a major factor in predicting future osteoporosis risk.[1,3] Beneficial bone effects of early childhood activity may persist beyond the period of the increased activity,[4] and several longitudinal studies have shown high childhood activity to be associated with high adult bone density.[5,6] The Department of Health and Human Services has recommended that physical activity levels increase in early childhood to optimize bone health.[7]

Walking is thought to place significant strain on bone, and adult studies have shown that walking enhances bone density.[8] Increased bone loading also is associated with increased bone size.[9] Theoretically, walking during infancy should exert the same effect by placing strains on the skeleton leading to a beneficial bone response, and walking at an earlier age will lead to greater cumulative loading than walking at a later age. In a longitudinal study of 20 children, Ruff investigated the relationship between body size, muscle size, and bone structural development and strength. Data were obtained from serial radiographs that were taken at approximately 6-month intervals from near birth to late adolescence.[10] He found that femoral bone strength velocity increased earlier during the second year with the beginning of walking, and humeral strength velocity declined as crawling stopped and assistance in standing and walking began. Because the peaks in bone strength velocities were not accompanied by changes in body size, Ruff suggested that bone strength is strongly dependent on mechanical loading.[10] This study is the only one that we are aware of that has examined the association between bone strength and the beginning of walking.

The aim of this study was to investigate the relationship between bone size and the onset of independent walking in preschool children, and to determine whether walking age explains the bone differences between preschool children born preterm compared with children born at term. We previously reported similar periosteal circumferences but larger

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| %BF | Percent body fat | pQCT | Peripheral quantitative computerized tomography |
| cortBA | Cortical bone area | | |

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Supported in part by a grant from the National Institutes of Health (R01-AR45310).

Submitted for publication Aug 23, 2006; last revision received Nov 14, 2006; accepted Feb 8, 2007.

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0022-3476/$ - see front matter

10.1016/j.jpeds.2007.02.033

endosteal circumference and smaller cortical area of the tibia in preschool children who were reported to be born preterm than in preschool children born at term.[11] In this study, we hypothesized that: 1) children who walk earlier will have larger periosteal circumference and cortical area and thickness and smaller endosteal circumference than children who walk later; and 2) children with history of preterm birth begin to walk at an older age compared with children born at term and this difference in walking age will explain the larger endosteal circumference and smaller cortical bone area that is observed in children with history of preterm birth.

## METHODS

Baseline data from 239 children aged 3 to 5 years who participated in a 1-year, randomized, placebo-controlled physical activity and calcium supplementation trial were used for this analysis.[11] Of the 239 children, 110 had tibia bone measurements with movement and were excluded from the study. A comparison between children who were excluded and those who were not showed that the children who were excluded were younger, lighter, and shorter (all $P < .001$). There were no differences in sex, history of preterm birth, physical activity levels, and walking age between children who were excluded and children who were not excluded.

Parents completed questionnaires that provided information on sex, race, feeding history during the first month of life, and parents' education. Parents were asked to recall the age the child first walked. Mothers also recalled whether the child was born early and, if so, how many weeks on the basis of their due date as determined by their obstetrician. Children were considered preterm when they were born ≤37 weeks gestation. The average length of prematurity was 4.1 ± 2 weeks. Fifty-six of the study participants were classified as Caucasian, and 8 were classified as non-Caucasian. Information on ethnicity and birth weight was not obtained. Although we did not collect specific information on whether the child was a multiple gestation, we did not have siblings with the same birth date in the study sample. Bone measurements with peripheral quantitative computerized tomography (pQCT) of the 20% distal tibia were obtained. pQCT measures included periosteal and endosteal circumferences, cortical thickness, and cortical bone area (cortBA). Settings for pQCT are described elsewhere.[15] Our coefficients of variation in children aged 3 to 5 years are 3.6% for periosteal circumference and 5.4% for cortBA. Percent body fat (%BF) measurements were obtained with dual energy x-ray absoptiometry whole body scans.[6,15] The total effective dose of radiation exposure from both the pQCT and dual energy x-ray absoptiometry was <1 mrem, which is significantly lower than the allowable effective dose of 500 mrem per year (National Council on Radiation Protection Report # 116).

Study participants wore accelerometers for a 48-hour period, and data were expressed as percent of time spent in moderate plus vigorous activity (counts >500/minute) or percent of time spent in vigorous activity (counts >1000/minute). Methods and validity of Actiwatch motion sensors have been described earlier.[11,16] Activity levels at baseline were available for 94% of the girls and 83% of the boys. Parents and child-care providers completed 3-day food records (2 weekdays and 1 weekend day). Records were reviewed for completeness by study personnel, and a nutrient intake analysis was performed with the Nutritionist V database (First Data Bank, San Bruno, CA). Quartiles of calcium intake (mg/day) were determined from lowest to highest as <709 mg/day, 709 to 875 mg/day, 876 to 1036 mg/day, and >1036 mg/d. The study was approved by the South Dakota State University Human Subjects Committee, and parental written informed consent was obtained.

Data were entered onto an Access database, and analyses were performed with JMP statistical software (SAS Institute, Cary, NC). Data were tested for normality and relationships between bone measures and anthropometric measurements (height, weight, %BF), demographic characteristics, and potential cofounders were examined. Data were stratified by sex caused by differences in bone measures, percent body fat, and activity levels. Significant predictors ($P \leq .05$) of periosteal and endosteal circumferences, cortBA, and cortical thickness were determined with stepwise regression analysis. Once multiple regression models for each of the outcome variables were obtained, walking age and gestation-corrected walking age were individually added to the model to determine whether either factor explained a significant amount of the remaining error. The significance of all 2-way interactions was tested for significance. Walking age was adjusted by subtracting the months born early (number of weeks/4.3) from walking age. Data given are mean ± SEM unless otherwise stated.

## RESULTS

There were 129 children with pQCT scans at baseline who had no movement. However, 1 of these children had a reported walking age of 7 months and an adjusted walking age of 5.6 months (<−3 SD from the mean). This was considered a recall error, and this child was excluded from the analysis. There were 64 girls and 14 children with a history of preterm birth. Overall, children with a history of preterm birth walked later than children with term birth (12.4 ± 0.5 versus 10.9 ± 0.2 months; $P = .004$), but this difference was not significant for gestation-corrected age at walking (11.4 ± 0.5 versus 10.9 ± 0.2 months; $P = .34$; Table I). There were no sex differences in any of the bone measures, although boys had lower %BF and greater activity levels than girls (Table I). In both boys and girls, bone measures were not associated with race, type of feeding during the first month, calcium intake, or season of enrollment.

### Boys

Preterm boys were older and had larger periosteal and endosteal circumferences than term boys (Table I). None of the bone measurements were associated univariately with walking age (Table II; available at www.jpeds.com). Periosteal circumference was univariately associated with weight (r =